MA 54: Spin-dependent transport phenomena

Time: Friday 8:00–10:00 Location: EB 301

MA 54.1 Fri 8:00 EB 301

Spin-dependent electrical transport of Heusler alloys at nonzero temperatures from the first principles — •David Wagenknecht, Karel Carva, and Ilja Turek — Department of Condensed Matter Physics, Faculty of Mathematics and Physics, Charles University, Prague, Czech Republic

Novel electrical and spintronic devices are required to operate at real-life conditions and to be reliable in a wide range of temperatures. Halfmetals are promising candidates for applications that manipulates with spin degrees of freedom and one of the most studied materials suitable for such usage are Heusler alloys.

We will present calculations of the electronic structure and electrical transport properties at nonzero temperatures of Heusler alloys like NiMnSb. The temperature-induced disorder, especially phonons, dramatically influence the properties. The approach is based on the fully relativistic tight-binding linear muffin-tin orbital (TB-LMTO) method with the coherent potential approximation (CPA) [1] and we will focus on the spin-dependent properties, e.g., electrical conductivity and spin-polarization [2].

The results will show a combined effect of the chemical, magnetic and temperature-induced disorder and a discussion of an efficiency of the spin-dependent transport for various disorders will be included. It may be used to design novel spintronic devices reliable at, e.g., room temperatures.

[1] K. Carva et al. Phys. Rev. B 73, 144421 (2006)
[2] D. Wagenknecht et al. Proc. SPIE 10357, 103572W (2017)

MA 54.2 Fri 8:15 EB 301

Perfect spin filter by periodic drive of a ferromagnetic quantum barrier — •Sebastian Eggert[1], Daniel Thuberg[2], Enrique Munoz[2], and Sebastian Reyes[2] — [1]TU Kaiserslautern and Research Center OPTIMAS — [2]Pont. Univ. Cat. de Chile, Santiago

We consider the problem of particle tunneling through a periodically driven ferromagnetic quantum barrier connected to two leads. The barrier is modeled by an impurity site representing a ferromagnetic layer or quantum dot in a tight-binding Hamiltonian with a local magnetic field and an AC-driven potential, which is solved using the Floquet formalism. Our results show that the time-periodic potential causes sharp resonances of perfect transmission and reflection, which can be tuned by the frequency, the driving strength, and the magnetic field. We demonstrate that a device based on this configuration could act as a highly-tunable spin valve for spintronic applications.

MA 54.3 Fri 8:30 EB 301

Current induced Néel-order switching in antiferromagnetic CuMnAs deposited by magnetron sputtering — •Tristan Matalla-Wagner, Jan-Michael Schmalhorst, Günter Reiss, and Markus Meinert — Center for Spinelectronic Materials and Devices, Bielefeld University, Germany

Antiferromagnets which fulfill certain symmetry properties allow for an intrinsic relativistic Néel-order spin-orbit torque (NSOT) driven by an electrical current [1]. The antiferromagnetically coupled sublattices of tetragonal CuMnAs are inversion partners and, thus, can experience a NSOT which can reorient the Néel vector $\boldsymbol{L}$ perpendicular to the applied charge current [2]. Therefore, this material is suitable to manufacture novel antiferromagnetic memory devices that are extraordinarily robust against external influences [3]. Here, we report on our experiments on the electrical switching of the Néel-order using short current pulses in highly oriented films of CuMnAs, deposited using dc-magnetron sputtering. Our findings corroborate the hypothesis of a thermally activated switching of $\boldsymbol{L}$ in CuMnAs, similar to the switching of sputtered Mn_2Au [4].

[1] J. Železný *et al.*, Phys. Rev. Lett. **113**, 157201 (2014)
[2] P. Wadley *et al.*, Science **351** 587 (2016)
[3] T. Jungwirth *et al.*, Nat. Nanotechn. **11** 231 (2016)
[4] M. Meinert *et al.*, arxiv.org/abs/1706.06983 (2017)

MA 54.4 Fri 8:45 EB 301

Anomalous Hall Effect in Cr_2O_3/Metal Thin Film Systems — •Asser Elsayed, Tobias Kosub, Jürgen Lindner, Jürgen Fassbender, and Denys Makarov — Helmholtz-Zentrum Dresden-Rossendorf e.V., Institute of Ion Beam Physics and Materials Research, Dresden, Germany

Antiferromagnetic thin films have recently shown their promise for applications, such as memory devices [1, 2]. One of these emerging concepts is the AF-MERAM, i.e. antiferromagnetic RAM that uses magnetoelectric materials such as Cr_2O_3.

An important aspect of memory devices is a strong readout signal. In an AF-MERAM the readout is done through a metal layer that is in contact with the boundary magnetization of Cr_2O_3 [3]. While reliable [1], the signal obtained in this way is quite weak. In order to increase the readout signal, we explore different metal layers in the Al_2O_3/Cr_2O_3/Metal stack, e.g. Pt, Ta and Pd, which have differently strong spin Hall and magnetic proximity effects.

[1] T. Kosub et al., Nature Commun. 8, 13985 (2017).
[2] T. Jungwirth et al., Nature Nanotech. 11.3, 231-241 (2016)
[3] T. Kosub et al., Phys. Rev. Lett. 115, 097201 (2015).

MA 54.5 Fri 9:00 EB 301

Temperature dependence of the generation and transport of pure spin currents using the spin Hall effect and spin injection — •Alexander Pfeiffer[1,2], Robert M. Reeve[1], and Mathias Kläui[1,2] — [1]Institut für Physik, Johannes Gutenberg-Universität Mainz, Mainz, Germany — [2]Graduate School of Excellence Materials Science in Mainz, Mainz, Germany

The spin Hall effect (SHE), observed in nonmagnetic heavy metals with large spin orbit coupling such as Platinum and Tungsten, has received remarkable recent interest as an attractive alternative to electrical spin injection for the generation of spin currents. Such spin currents can be employed to switch magnetic bits efficiently in low power data storage devices [1]. Given surprising results of the temperature dependence of spin current generation and transport in lateral spin valves [2], we study multi-terminal Py-Pt-Cu based lateral spin valve structures. We inject spin currents into the Copper via both the SHE in Platinum and spin injection from Permalloy and compare both conventional non-local signals and those generated via the inverse spin Hall effect (iSHE) in a single device as a function of temperature. We observe a different temperature behaviour in the different cases, which we explain by the different mechanisms occuring in the Platinum and Permalloy and highlighting the governing temperature dependence of the spin injection rather than the spin transport as previously expected. [1] N. Motzko et al., Phys. Rev. B 88, 214405 (2013) [2] A. Pfeiffer et al., Appl. Phys. Lett 107, 082401 (2015)

MA 54.6 Fri 9:15 EB 301

Topological and anomalous Hall and Nernst effect in Mn_3X ($X = Ge$ and Sn) — •Ilias Samathrakis[1], Jürgen Weischenberg[2], and Hongbin Zhang[1] — [1]Institute of Materials Science, TU Darmstadt, 64287 Darmstadt, Germany — [2]Department of Physics, RWTH Aachen University, 52074 Aachen, Germany

Antiferromagnets have recently become a hot research topic for spintronic applications. Unlike ferromagnets, they are robust against perturbations due to magnetic fields. Consequently, non-collinear magnets have also attracted some interest, being part of the antiferromagnetic spintronics. An interesting series of non-collinear antiferromagnets that has been extensively studied is Mn_3X ($X = Ge$ and Sn). The combination of magnetic frustration and the relatively small energy difference among possible magnetic configurations make them ideal candidates. Till now, a consistent theory for the angular dependence of the anomalous hall conductivity and its physical origin is still missing. In this work, we performed calculations on both the intrinsic and the side-jump contributions, with (anomalous), as well as without (topological) spin-orbit coupling. It is observed that the angular dependence of the anomalous Hall conductivity is unusual. Detailed comparison between Mn_3Ge and Mn_3Sn is shown focusing on the magnitude of their anomalous Hall and anomalous Nernst effects, where significant side jump contribution due to impurities.

MA 54.7 Fri 9:30 EB 301

Growth, structural characterisation and magnetotransport measurements in Mn_3X (X = Ir, Ge) thin-films — •James M Taylor[1], Edouard Lesne[1], Anastasios Markou[2], Pranava K Sivakumar[1], Fasil K Dejene[1], Claudia Felser[2], and Stuart S P Parkin[1] — [1]Max Planck Institute for Microstructure Physics, D-

06120 Halle, Germany — [2]Max Planck Institute for Chemical Physics of Solids, 01187 Dresden, Germany

Antiferromagnetic (AFM) materials have undergone a resurgence in interest due to their potential applications in spintronic devices operating without net magnetization. Non-collinear AFMs are particularly promising, with the topological character of their chiral spin texture yielding novel phenomena such as a large anomalous Hall effect and an intrinsic spin Hall effect.

In this work, we report the magnetron sputtering growth of thin-films of the non-collinear AFMs Mn_3Ir and Mn_3Ge. Structural characterisation demonstrates epitaxial (111) and (001) texture in Mn_3Ir and hexagonal Mn_3Ge. Measurements of magnetic properties are shown, including XMCD and exchange bias fields up to H_{Ex} = 306 Oe when coupled to a ferromagnetic (FM) layer.

Finally we present electrical transport measurements, as a function of temperature and applied magnetic field, in lithographically patterned devices. Anomalous Hall effect (modifiable by a layer with strong spin-orbit coupling) is observed at low-temperatures, and spin Hall magnetoresistance investigated in AFM-FM bilayers. Possible origins of these effects, including interfacial contributions, are discussed.

MA 54.8 Fri 9:45 EB 301

Theoretical description of the electric-field induced XMCD at a ferromagnet/non-magnet interface — •Alberto Marmodoro, Sebastian Wimmer, and Hubert Ebert — Dept. Chemie, LMU, München

Bidimensional heterostructures composed of magnetic and non-magnetic materials allow to investigate how spin polarization effects do not cease abruptly at the interface, but extend across it and give rise to a variety of phenomena, that are typically controlled by the details of composition and geometry. Recent experiments [1-2] have furthermore explored how this situation is changed by application of an electric field that drives a steady flux of carriers through the subsystems, and thus go well beyond a ground state regime. We consider in particular X-ray absorption (XAS) and magnetic circular dichroism (XMCD) measurements [3] which can provide element -resolved insight on spin accumulation and its dependence on the direction and magnitude of an external stimulus on top of static, proximity induced influences. This setup is investigated within the spin-polarized relativistic multiple scattering framework (SPRKKR) making use of recent developments [4-5] for the non-equilibrium Green function (NEGF) description of spectroscopy in real materials.

(1) R. Kukreja et al., Phys.Rev.Lett. **115**, 096601, (2015)
(2) G. van der Laan, Physics **8**, 83, (2015)
(3) H. Ebert, Rep.Prog.Phys. **59**, 1665, (1996)
(4) S. Achilles et al., Phys.Rev.B **88**, 125411, (2013)
(5) M. Ogura et al., J.Phys.Soc.Japan **85**, 104715, (2016)